Design Characteristics of an Oxy Combustion Steam Plant for Canadian Oil Sands with a Focus on Sustainability

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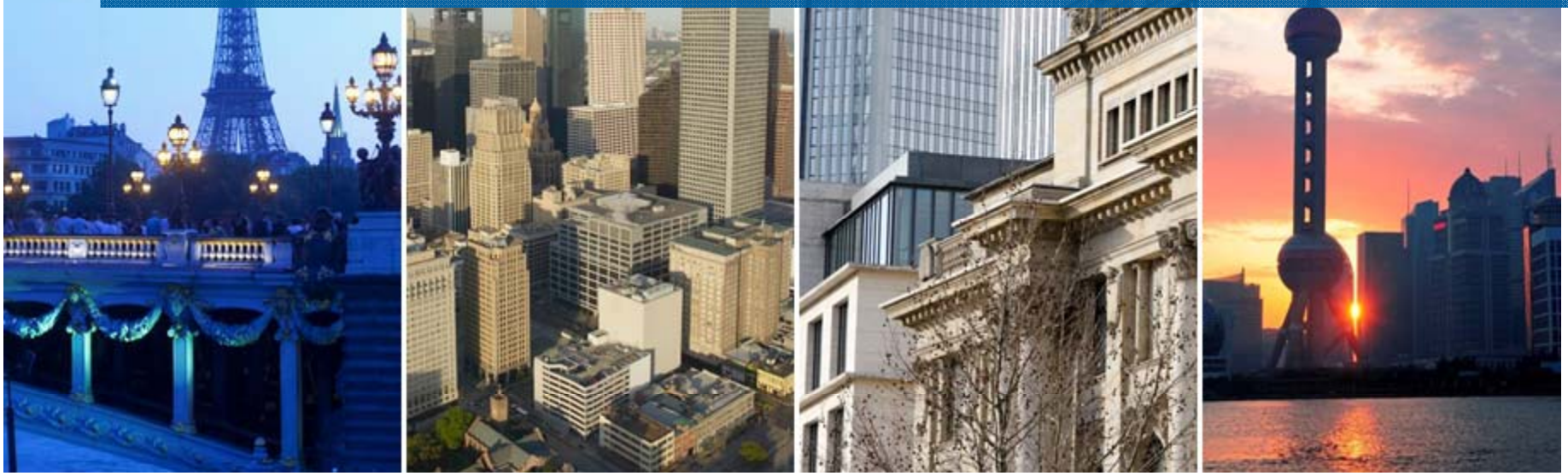

Agenda

- Context – Oil Sands & Steam Assisted Gravity Drainage
- Base case description
  - Air boilers
  - Steam production
- Oxy case description
  - Details on oxy burners
  - Details on oxy boilers
  - Details on ASU
  - Details on CPU
- Results & path forward

Context – Athabasca Oil Sands

Steam Assisted Gravity Drainage

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Athabasca Oil Sands & SAGD

- **Athabasca Oil Sands = Northern Alberta Bitumen reserve**
- **Represents more than 70% of world's bitumen reserve**
- **Energy intensive / carbon intensive extraction process: SAGD (Steam Assisted Gravity Drainage)**
  - **In addition to energy efficiency improvements, CCS a potential solution to reduce environmental impact**
- **Joint effort to develop a Sustainable way to use the SAGD process between Statoil RDI, Babcock & Wilcox and Air Liquide**
  - **Oxy-combustion boilers with CCS to produce carbon-free steam**
  - **Case study:**
    - **Generic 40,000 bbl/day SAGD facility**
    - **875 tonnes/day steam consumption**

Base case description

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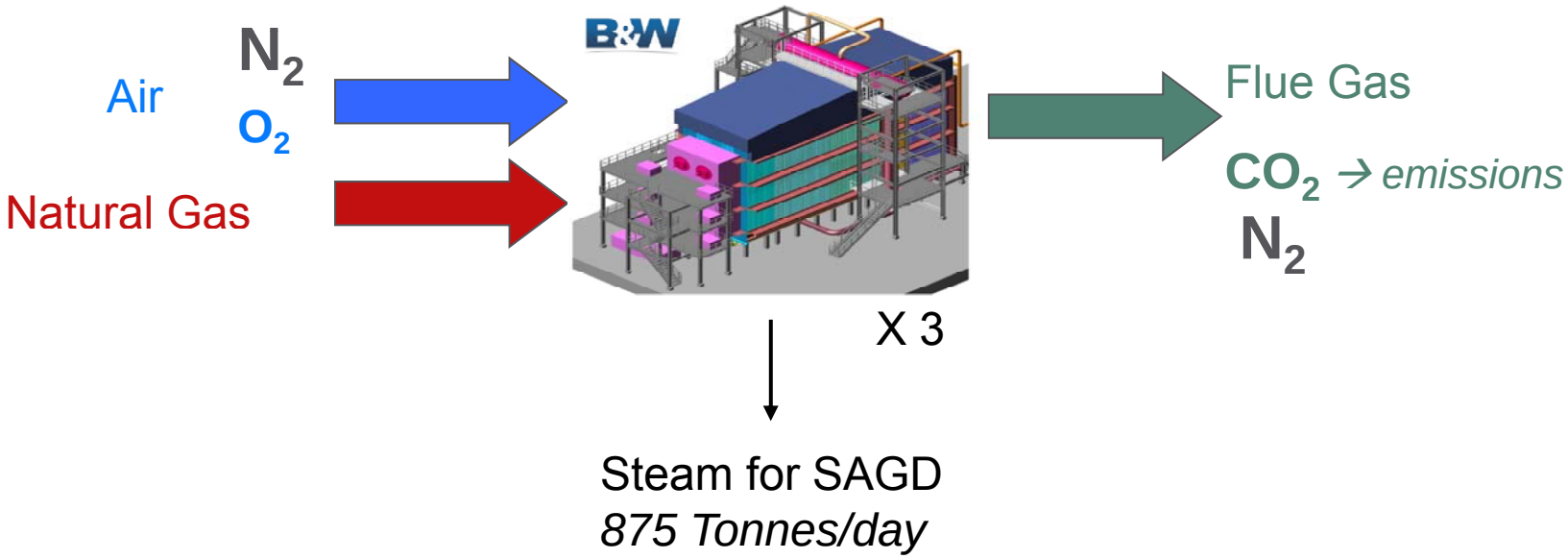
Reference case

- **Reference scheme - air case**

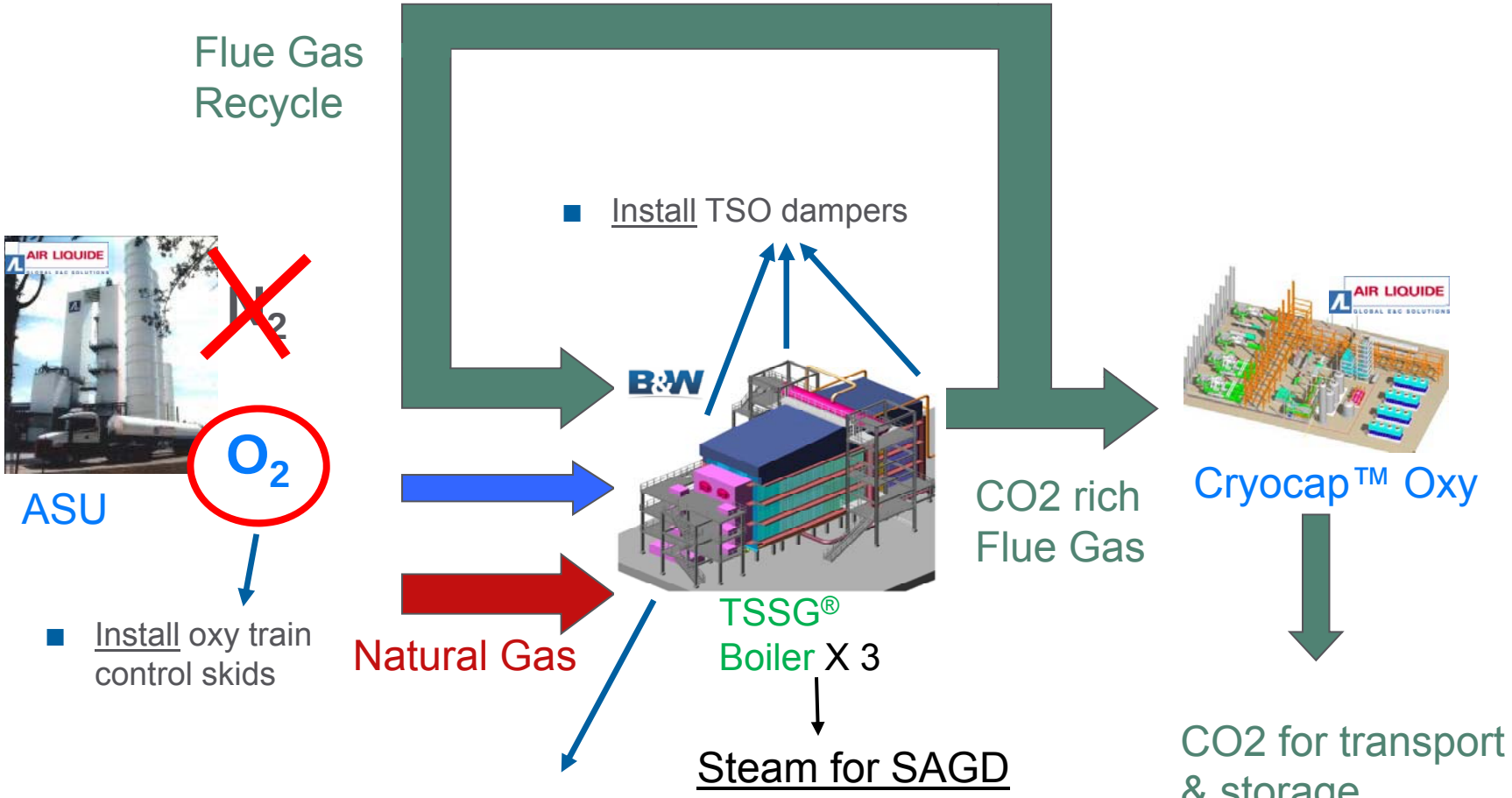


Initial boiler design – 100% air combustion

- 3 identical TSSG® boilers - 875t/hr saturated steam at 91 bar & 304°C
- Specifically designed for oil sands
  - Tranport constraints
  - Robust design can accept « Sub-ASME » water quality from water treatment evaporator including multi-circ concept
- High efficiency
  - Low boiler blowdown (2.5 to 5% of steam flow) to conserve water
  - Incorporating glycol gas/air heater to boost boiler efficiency
- Ultra low NOx combustion burners with FGR to meet Alberta's stringent NOx emissions requirement (15.8 g/GJ)
- Incorporating features ready for future conversion to oxy combustion with minimum modifications to the boiler to accomodate oxy burners

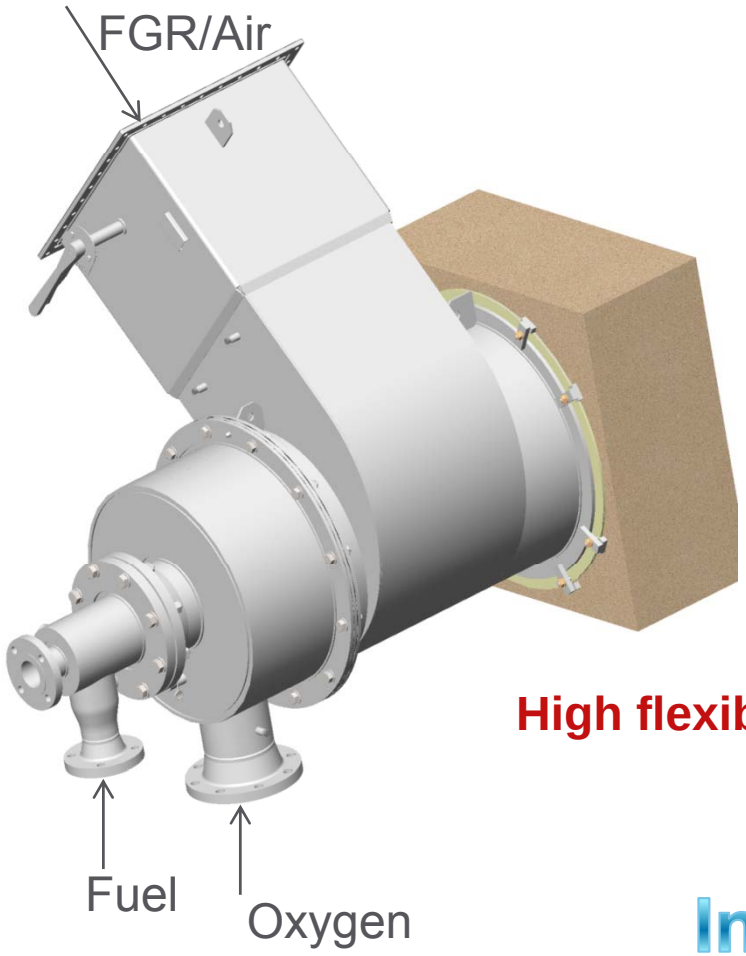
Oxy-combustion solution description

Oxy-combustion case – general scheme



- Replace air burners with Air Liquide's flexible oxy/air burners
  - Modify windbox and burner opening
  - Add FGR feeders to each burner

Flexible air / oxy burners



Efficient design
- Low CO production
- Low NOx (O2 / air staging, FGR use)

Compact design
- Compliant with pressure drop specs
- Optimized burner-burner spacing
- Controlled flame shape and interaction

Flexible design
- No mixing of FGR with oxygen
- Wide range of FGR rate acceptable
- Oxy / air flexibility

High flexibility of operation with excellent performance

Interesting alternative for capture ready projects

Oxy/Air combustion boilers

- Switching between air and oxy combustion modes and vice versa possible while the boiler is online
- Boiler is operated in positive pressure to eliminate air infiltration to boiler
- 2% higher boiler efficiency in oxy combustion as compared to air combustion

Technology qualification

- B&W TSSG® boilers
  - 1100 T/h total capacity in operation in Alberta Oil Sands (add 1100 T/h coming on-line 2014-15)
  - AL flexible Oxy/air burners for similar application demonstrated at Lacq
- ASU technology
  - Fully qualified improvements to commercial technology
  - Air Liquide referenced for large scale ASU in Alberta
- Cryocap™ Oxy technology
  - All technology bricks demonstrated in representative or more stringent conditions through various demo plants

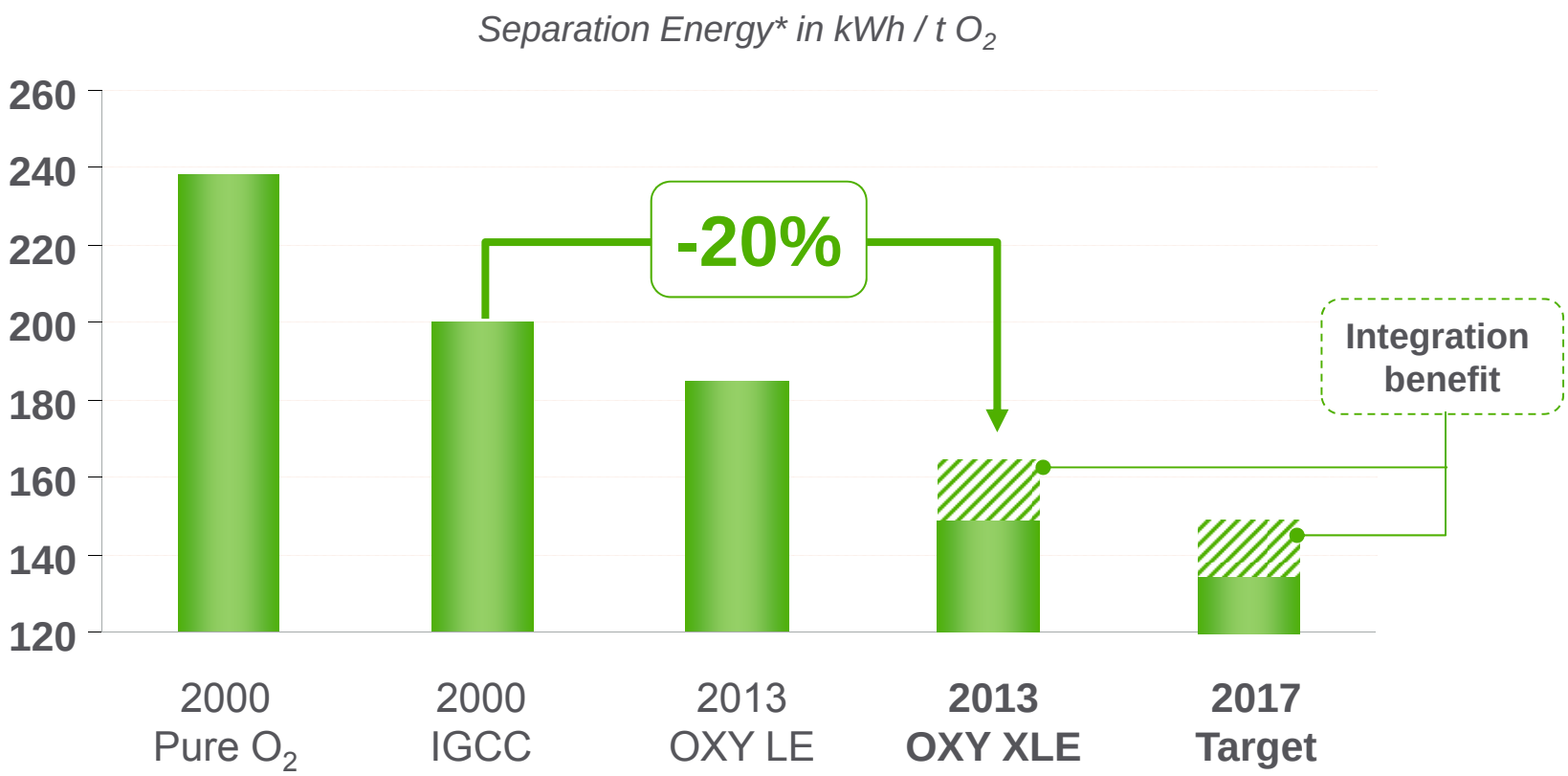
Total Lacq

Callide

Ciuden

High efficiency ASU for oxy-combustion

- Oxy combustion
  - ASU design = air distillation at lowest possible pressure (< 4bara)



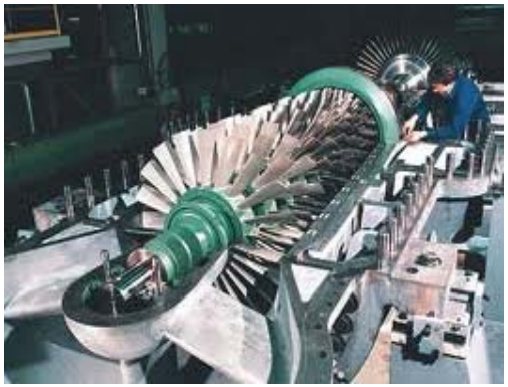
** Compression energy not included, calculated at 15°C, 1 atm, 60% humidity*

ASU: High energy efficiency solution for SAGD

- ASU efficiency chosen: XLE solution
  - Very efficiency ASU: Specific energy < 170 kWh/tonne (w/o heat integration)
- Cold atmospheric conditions (Alberta)

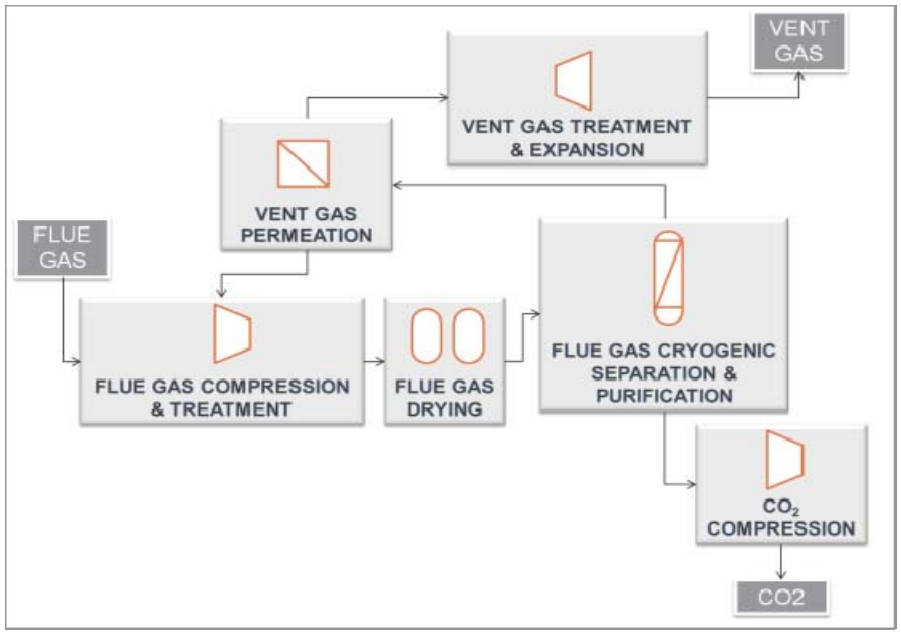
  ➔ reduced energy consumption

- Compressor technology
  - Axial machine → high efficiency



Cryocap™ Oxy: Air Liquide's solution for FG Compression & Purification

- Cryocap™ Oxy scheme



- Natural gas flue gas = Clean flue gas (ex: no SOx treatment needed)
- Near Zero Emissions* of CO_2, CO, NO_x
- High energy efficiency
  - Separation + compression energy < 125 kWh/tonne

* See dedicated AL presentation

Results & Path forward

Viability of oxy-combustion for SAGD

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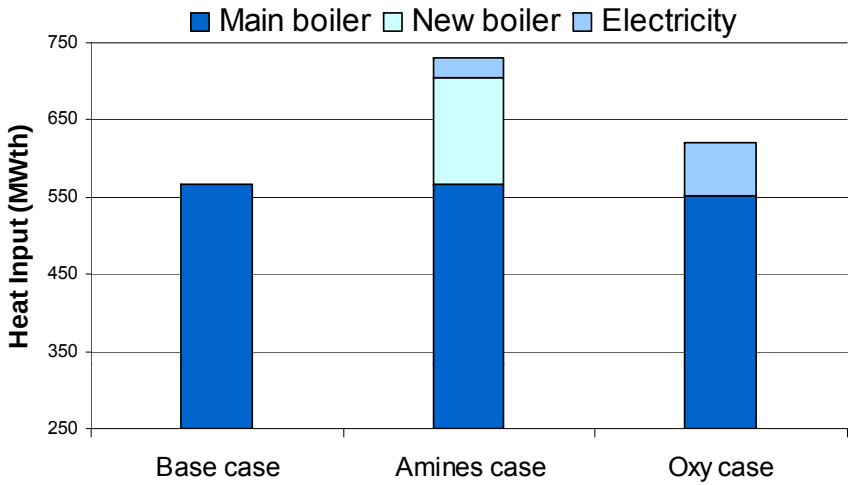
Capture rate

- From direct emissions: ability to capture 98% of the CO_2
- CO_2 intensity of electricity is critical in the overall carbon footprint
  - Today's CO_2 intensity in Alberta > 1 tonne of CO_2 / MWh
  - Alberta objectives of CO_2 intensity reduction will reduce carbon footprint greatly

Efficiency comparison between post and oxy

- Comparison with a post-combustion case (amines)
  - Extra boiler for production of regeneration steam
  - Capture from all boilers
- Conversion of all consumers into heat input



- CO_2 avoided Specific Energy Consumption

		Amines case	Oxy case
CO_2 capture SEC	GJ_{th} / tonne	4,8	2,0
CO_2 avoided SEC	GJ_{th} / tonne	6,5	2,2

Conclusions

- Fully integrated oxy-combustion SAGD plant with CO_2 capture is feasible
- All components in an oxy SAGD is ready for demonstration in full scale
- Efficiency of oxy-combustion solution is significantly better than efficiency of post-combustion solution for a SAGD facility where surplus LP steam is not available
- Solution is ready for broad adoption upon sufficient CO_2 tax / legislation deployment

End of presentation
Thank you for your attention

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